

## GULF OF ALASKA FLATFISH

by

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### SUMMARY

Catch has been updated through October 5, 2002. The 2001 survey biomass estimates were used to calculate ABC's for 2003 for all species except Greenland turbot and deepsea sole, where the mean catch from 1978 to 1995 was used. ABC estimates were not changed from last year's assessment (Turnock, et al 2001) since there was no new survey data, except for Northern and Southern rock sole where new maturity information allowed the estimation of F40% and F35%.

Catches for species in the deep-water or shallow-water groups were estimated from 1978 to 2002 by multiplying the group catch estimate by the estimate of the fraction of each species in the catch based on observer data.

The 2001 Triennial trawl survey biomass was used as current biomass for calculation of ABC. Greenland turbot and deepsea sole ABC and OFL were calculated using average catch. ABC's for other flatfish except rock sole were estimated using  $F = 0.75 M$ . The 2003 ABC estimates are the same as the 2002 ABCs since no new survey data is available, except for northern and southern rock sole where new fishing mortality values were estimated. The 2003 ABC for deep-water flatfish declined to 4,877 t, from the 2001 ABC of 5,300 t. The 2003 ABC for shallow-water flatfish decreased slightly to 49,349 t from 49,546 t in 2002, due to different fishing mortality values used for northern and southern rock soles. The 2003 ABC for rex sole was 9,466 t, the same as in 2002, and essentially unchanged from the 2001 ABC of 9,442 t.

The flatfish resource was lightly to moderately harvested in 2002 as the shallow-water, deep-water, flathead sole and rex sole ABC apportionments were 19%, 18%, 6%, 38% harvested through October 5, respectively. The 2002 catches were similar to the 2001 catches. Catches in the deep-water complex declined from 2,285 t in 1999 to 804 t in 2001, then were 546 t in 2002 (through October 5, 2002). Shallow-water flatfish catches increased from 2,577 t in 1999 to 6,928 t in 2000, then decreased to 6,195 t in 2002 (through October 5, 2002). Rex sole catches increased slightly from 3,060 t in 1999 to 3,591 t in 2000, then declined to 2,941 t in 2002 (through October 5, 2002).

## INTRODUCTION

The "flatfish" species complex has been managed as a unit in the Gulf of Alaska and includes the major flatfish species inhabiting the region with the exception of Pacific halibut (*Hippoglossus stenolepis*). The major species, which account for 98% of the current biomass, are arrowtooth flounder (*Atheresthes stomias*), flathead sole (*Hippoglossoides elassodon*), northern rock sole *Lepidopsetta polyxystra*, southern rock sole *Pleuronectes bilineata*, rex sole (*Errex zachirus*), Dover sole (*Microstomus pacificus*), yellowfin sole (*Pleuronectes asper*), and starry flounder (*Platichthys stellatus*). The arrowtooth flounder and flathead sole stock assessments are presented in separate chapters.

The North Pacific Fisheries Management Council divided the flatfish assemblage into four categories for management in 1990; "shallow flatfish" and "deep flatfish" (Table 3.1), flathead sole and arrowtooth flounder. This classification was made because of the significant difference in halibut bycatch rates in directed fisheries targeting on shallow-water and deep-water flatfish species. Arrowtooth flounder, because of its present high abundance and low commercial value, was separated from the group and managed under a separate acceptable biological catch (ABC). Flathead sole were likewise assigned a separate ABC since they overlap the depth distributions of the shallow-water and deep-water groups.

In 1993 rex sole was split out of the deep-water management category because of concerns regarding the Pacific ocean perch bycatch in the rex sole target fishery. For this assessment, flatfish biomass, fishing mortality rates, and ABC estimates are presented for each species and management category.

Beginning with the 1996 triennial trawl survey, rock sole was split into two species, a northern rock sole and a southern rock sole. Due to overlapping distributions, differential harvesting of the two species may occur, requiring separate management in the future.

This report describes flatfish catches taken from 1978 through October 5, 2002 and presents information on the status of flatfish stocks and their potential yield based on data updated through the 2001 Gulf of Alaska demersal trawl survey.

## CATCH HISTORY

Since the passage of the MFMCA in 1977, the fishery for flatfish in the Gulf of Alaska has undergone changes. Until 1981, annual harvests were around 15,000 t (including arrowtooth flounder), primarily taken by foreign vessels targeting other species (Table 3.2). Thereafter, catches decreased to a low of 2,441 t in 1986 before increasing to a high of 43,107 t in 1996. Flatfish catches declined to 23,237 t in 1998, increased to 37,303 t in 2000, then declined to 30,720 t in 2002. With the cessation of foreign fishing in 1986, joint venture fishing began to account for the majority of the catch. In 1987, the gulf-wide flatfish catch increased nearly fourfold to 9,925 t with the joint venture fisheries accounting for nearly all of the increase (73% of the gulf-wide catch). After 1988, only domestic fleets harvested flatfish.

The NPFMC Central Gulf management area has produced the majority of the flatfish catch from the Gulf of Alaska (Table 3.2). Since 1988 the majority of the harvest has occurred on the continental shelf and slope east of Kodiak Island. Although arrowtooth flounder comprised about half the catch, the fishery primarily targeted on rock, rex and Dover sole (Table 3.3).

Catch is currently reported for deep-water flatfish, shallow-water flatfish, flathead sole and rex sole by management area (Table 3.3). The catch by species in each year was estimated by using the fraction of each species in their respective group from observer sampling in that year, multiplied by the total catch for that group by gear type and management area (i.e. deep-water or shallow-water group, Tables 3.4 and 3.5). The blend estimate of catch is used as the estimate of total catch. Catches for the deep-water

species were estimated from 1978 to 1995 for estimation of the average catch used in ABC calculations (Table 3.6). Most of the catch in the deep-water group has been Dover sole. However, Greenland turbot catch has been quite variable, ranging from 3,012 t in 1992 to 13 t in 1997 (Table 3.6). Table 3.7 documents annual research catches (1977 - 1998) from NMFS longline, trawl, and echo integration trawl surveys.

The flatfish resource was lightly to moderately harvested in 2002 as the shallow-water, deep-water, and rex sole ABC apportionments were 13%, 11%, 31%, harvested through October 5, respectively. The 2002 catches were similar to the 2001 catches, except deep-water flatfish, which was lower in 2002. The 2002 deep-water flatfish and rex sole fisheries were closed in each quarter on May 24, August 2, and October 13 to prevent exceeding the halibut bycatch limit. The entire GOA was closed to trawling for flatfish on October 13 due to reaching the halibut bycatch limit. The 2002 shallow-water flatfish fishery was closed on May 15, August 5, and October 13 due to the attainment of the halibut bycatch limit.

Catches in the deep-water complex declined from 2,285 t in 1999 to 985 t in 2000, and have continued to decline to 546 t through October 5, 2002 (Table 3.3). Shallow-water flatfish catches increased from 2,577 t in 1999 to 6,928 t in 2000, then decreased to 6,195 t through October 5, 2002. Rex sole catches increased slightly from 3,060 t in 1999 to 3,591 t in 2000, then declined to 2,941 t through October 5, 2002. The flatfish fishery is likely to continue to be limited by the potential for high by-catches of Pacific halibut.

Estimates of retained and discarded catch (t) in the various trawl target fisheries, since 1991, by management assemblage, were calculated from discard rates observed from at-sea sampling and industry reported retained catch (Table 3.8). Retention of deep-water flatfish declined from 75% in 2001 to 64% in 2002. Retention of shallow water flatfish was unchanged from 2001 at 91% for 2002. Retention of rex sole was also unchanged at 95% for 2002.

## **CONDITION OF STOCKS**

### **Survey Abundance**

The principal source of information for evaluating the condition of flatfish stocks in the Gulf of Alaska is the bottom trawl survey conducted from 1984 to 2001 (Table 3.9 and Figure 3.1). Flatfish biomass estimates from the 2001 survey by INPFC area are given in Table 3.10. Sampling for the 2001 survey was conducted in the western and central portions of the gulf only. Biomass for the eastern gulf was approximated using the average of the 1993 to 1999 eastern gulf biomass estimates for all flatfish species except Dover sole, butter sole and English sole (Table 3.11). A significant proportion of the survey biomass is in the eastern gulf for Dover sole and English sole, while for other species the proportion is low. The average of the 1993 to 1996 eastern gulf biomass was used for most species because there was no discernable trend in abundance, or there did not appear to be any correlation in biomass between areas (Tables 3.10 to 3.14). Dover sole and butter sole seemed to show similar trends in biomass in the eastern and central areas, so eastern gulf biomass estimates for 2001 were obtained by applying the decline in biomass from 1999 to 2001 in the central gulf to the 1999 biomass in the eastern gulf. Both the central and eastern areas showed similar trends for English sole, and the central biomass was very similar from 1999 to 2001, so the eastern gulf biomass for 1999 without any adjustment was used as the estimate for the eastern gulf in 2001.

The apportionment of survey sampling stations on the shelf and slope followed the methods developed for the shelf portion of the 1984 survey (Brown 1986). There was no sampling deeper than 500 meters during 1990 to 1996, and 2001 because of limited vessel time. The 500- 1,000 m depths sampled in 1984 and 1987, and 1999 are generally outside the depth range of most flatfish species with the exception of Dover sole, Greenland turbot, deep-sea sole and, to a lesser extent, Rex sole. Dover sole move to deeper

water as they grow, however, most of the biomass is in the 100 to 200 meter depth range (Figure 3.4). The biomass in waters greater than 500 m declined from about 20,000 t in 1984 (30% of the total biomass) to 7,000 t in 1999 (10% of the total biomass). Total Dover sole biomass was higher in 1999 (about 74,400 t) than in 1984 (about 68,500 t).

Many flatfish species have an increasing trend in biomass in the 1980's and then a decreasing trend in the 1990's. Survey biomass has declined for Dover sole from 96,602 t in 1990 to 68,211 t in 2001. Northern rock sole declined from 78,845 t in 1996 to 64,240 t in 2001. Southern rock sole declined from 127,390 t in 1996 to 105,522 t in 1999, then increased to 126,057 t in 2001. Flathead sole declined from 247,247 t in 1990 to 170,915 t in 2001. Rex sole declined from 95,630 t in 1990 to 71,326 t in 2001. Yellowfin sole declined from 81,329 t in 1993 to 48,309 t in 1999, then increased slightly to 55,303 t in 2001. Butter sole has steadily declined from 29,809 t in 1993 to 9,812 t in 2001. Starry flounder biomass has increased from 10,907 t in 1990 to 46,652 t in 1999 and continued to increase to 76,418 t in 2001. English sole increased in abundance from 8,403 t in 1993 to 14,433 t in 1999, then remained steady at 14,166 t in 2001. Alaska plaice has also increased in abundance from 2,583 t in 1993 to 8,680 t in 1999, then declined to 3,639 t in 2001. Sand sole has been quite variable over time, most recently increasing from 234 t in 1999, to 357 t in 2001.

#### Current Exploitable Biomass

With the exception of Greenland turbot and deep-sea sole, the best available estimate of current exploitable biomass is assumed to be the same as the survey biomass from 2001 because the non-exploitable (< 30 cm) component of the survey biomass is small and the survey bottom trawl (90 x 105 ft. Noreastern trawl with roller gear) is only partially selected for non-exploitable sizes.

Recent experimental evidence suggests that flatfish biomass estimates derived from the noreastern trawl used in the survey may underestimate true biomass because the escapement portion of the catchability assumption may be large (Weinberg, in review). Experiments are needed to estimate the herding component of catchability, which may offset some of the escapement.

### **BIOLOGICAL PARAMETERS**

#### Natural mortality, Age of recruitment, and Maximum Age

Natural mortality rates for Gulf of Alaska flatfish species were estimated using the methods of Alverson and Carney (1975), Pauly (1980), and Hoenig (1983) in the 1988 assessment (Wilderbuer and Brown 1989). The estimates were different for each method and were not inconsistent with the value of 0.2, used in previous assessments (Wilderbuer and Brown 1989). A natural mortality value of 0.2 was used for all flatfish except Dover sole (Table 3.15). Natural mortality for Dover sole was assumed to be 0.10, the same as West Coast Dover sole because maximum age is about 45 years (Turnock, et al 1994).

#### Length and Weight at Age

Values for the parameters in the Von Bertalanffy age-length relationship were estimated from age structures collected during the trawl surveys (Table 3.16). Length composition data from the triennial surveys are shown in Figure 3.2. Aging of Gulf of Alaska flatfish species has been sporadic since the inception of the triennial surveys. Estimates of survey age compositions for flatfish are shown in Figure 3.3.

The parameters calculated for the length (cm) - weight (g) relationship:  $W = a * L^b$  (both sexes combined) are shown below.

Species	a	B
Rock sole	0.009984	3.0468
Yellowfin sole	0.006678	3.1793
Rex sole	0.004459	3.4710

### Maturity at Age

Maturity at age and size have been estimated for arrowtooth flounder, flathead sole, and northern and southern rock sole. Maturity data for Dover and rex sole are being analyzed. Northern rock sole females from the Kodiak Island area Alaska, reached 50% maturity at 328 mm and an average age of 7 years. In contrast, southern rock sole females reached 50% maturity at 347 mm and an average age of 9 years (Stark and Somerton 2002). Northern rock sole females grew faster overall ( $K=0.24$ ) than southern rock sole females ( $K=0.12$ ) but reached a smaller maximum length ( $L_{inf}=430$  mm) than southern rock sole ( $L_{inf}=520$ mm).

### Food habits

Flatfish consume a variety of benthic organisms (Table 3.18; Livingston and Goiney 1983, Yang 1990). Fish prey make up a large part of the diet of flathead sole and rock sole adults and possibly sand sole (although the sample size was small for sand sole). Other flatfishes consume mostly polychaetes, crustaceans and mollusks.

## ACCEPTABLE BIOLOGICAL CATCH

Northern and southern rock sole are in tier 4 of the ABC and overfishing (OFL) definitions, where  $F_{ABC} = F_{40\%}$  and  $F_{OFL} = F_{35\%}$ . Northern and southern rock sole were estimated to be approximately fully selected in the survey at about 32 cm (age 7 and 8, respectively), by visual examination of size compositions from the fishery and applying the growth curve. Selectivities were applied as knife-edge for calculation of  $F_{40\%}$  and  $F_{35\%}$ . Southern rock sole  $F_{40\%} = 0.162$ ,  $F_{35\%}=0.192$ , northern rock sole  $F_{40\%}= 0.204$  ,  $F_{35\%}= 0.245$ .

ABCs for all flatfish, except rock soles, deep-sea sole and Greenland turbot, were calculated using  $F_{ABC} = 0.75 M$  and  $F_{OFL} = M$  (tier 5), since maturity information was not available. Natural mortality was assumed to be 0.2 for butter sole, starry flounder, English sole, Alaska plaice, and sand sole. Greenland turbot and deep-sea sole are in tier 6 since there are no reliable biomass estimates, where  $ABC = 0.75 OFL$  and  $OFL =$  the average catch from 1978 to 1995 (Table 3.6).

Recommended fishing mortality rates for 2001 ABCs are as follows:

Species	$F_{ABC}$	$F_{OFL}$
Southern rock sole	0.162	0.192
Northern rock sole	0.204	0.245
Yellowfin sole	0.15	0.2
Rex sole	0.15	0.2
Dover sole	0.075	0.1
All other flatfish (except Greenland turbot and deep-sea sole)	0.15	0.2

The flatfish complex ABCs for the 2003 fishing season were calculated using the catch equation, the  $F_{ABC}$  fishing mortality rate, and the 2001 survey biomass estimate for each species, (Table 3.19) except for Greenland turbot and deep-sea sole where average catch was used. Overfishing values and yield are presented in Table 3.20.

The 2003 ABC values were the same as the 2002 ABCs except for northern and southern rock sole which are in the shallow water flatfish group. The 2003 ABC for deep-water flatfish declined to 4,877 t, from the 2001 ABC of 5,300 t. The 2003 ABC for shallow-water flatfish decreased slightly to 49,349 t from the 2001 ABC of 49,546 t. The 2003 ABC for rex sole was 9,466 t, the same as the 2002 ABC, and essentially unchanged from the 2001 ABC of 9,442 t.

Due to the overlapping distributions of flatfish species, especially in the shallow-water group, it may be difficult to target a species within an arbitrary management group without impacting other flatfish species in that group or other species which were "split-out" and managed separately. Given the present management strategy used by the North Pacific Fishery Management Council for Gulf of Alaska flatfish, some species may be subjected to higher fishing mortalities than that resulting from the recommended ABCs. Even the most abundant species of the shallow-water category, rock sole, could be over-harvested given the present species grouping because the harvest level for a management group is based on the composite biomass of several species.

### BIOMASS PROJECTIONS

The exploitable biomass in the year 2004 is projected using the delay difference equation of Deriso (1980). This model incorporates growth, natural mortality, recruitment, and two years of biomass estimates (1999 and 2001 trawl surveys) to predict future biomass (Table 3.21). Exploitable biomass is predicted under harvest strategies of  $F=0$ ,  $F_{ABC}$ ,  $0.5 * F_{ABC}$ , and the average  $F$  from 1995 to 1999. Recruitment biomass is assumed to be constant during the projected years and was approximated from the 1999 Gulf of Alaska trawl survey biomass due to the lack of data in the eastern gulf for the 2001 survey.

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Table 3.1. Flatfish constituents of the 1996 NPFMC Gulf of Alaska deep-water and shallow-water management categories.

Category	Common name	Genus and Species
Deep-water		
	Dover sole	<u><i>Microstomus pacificus</i></u>
	Greenland turbot	<u><i>Reinhardtius hippoglossoides</i></u>
	Deep-sea sole	<u><i>Embassichthys bathybius</i></u>
Shallow-water		
	Northern rock sole	<i>Lepidopsetta polyxystra</i>
	Southern rock sole	<u><i>Pleuronectes bilineata</i></u>
	Yellowfin sole	<u><i>Pleuronectes asper</i></u>
	Starry flounder	<u><i>Platichthys stellatus</i></u>
	Butter sole	<u><i>Pleuronectes isolepis</i></u>
	English sole	<u><i>Pleuronectes vetulus</i></u>
	Alaska plaice	<u><i>Pleuronectes quadrituberculatus</i></u>
	Sand sole	<u><i>Psettichthys melanostictus</i></u>

Table 3.2. Catch (t) of flatfish in the Gulf of Alaska (including arrowtooth flounder), by North Pacific Fishery Management Council Regulatory Area, 1978 to November 3, 2001. (Includes discards 1992-2001).

Fishery category	Western	Central	Eastern	Total
<b>Foreign</b>				
1978	2,538	6,312	5,491	14,341
1979	2,817	5,026	5,631	13,474
1980	3,022	6,885	5,590	15,497
1981	3,224	5,759	5,461	14,444
1982	1,412	7,516	58	8,986
1983	2,020	7,459	51	9,530
1984	603	2,430	0	3,033
1985	115	55	0	170
1986a	56	15	0	71
<b>Joint venture</b>				
1978	5	0	0	5
1979	7	62	1	70
1980	11	198	0	209
1981	0	18	0	18
1982	6	12	0	18
1983	171	2,521	0	2,692
1984	566	2,882	0	3,448
1985	324	2,123	0	2,447
1986	302	659	0	961
1987	2,073	5,134	0	7,207
1988b	tr	1,780	0	1,781
<b>Domestic</b>				
1978	6	86	760	852
1979	0	55	329	384
1980	0	46	94	140
1981	0	77	327	404
1982	0	71	203	274
1983	0	88	351	439
1984	5	246	181	432
1985	10	254	197	461
1986	362	774	273	1,409
1987	184	2,001	533	2,718
1988	810	7,223	461	8,494
<b>Total</b>				
1978	2,549	6,398	6,251	15,198
1979	2,824	5,143	5,961	13,928
1980	3,033	7,129	5,684	15,846
1981	3,224	5,854	5,788	14,866
1982	1,418	7,599	261	9,278
1983	2,191	10,068	402	12,661
1984	1,174	5,558	181	6,913
1985	449	2,432	197	3,078
1986	720	1,448	273	2,441
1987	2,257	7,135	533	9,925
1988	811	9,003	461	10,275
1989c	142	4,888	187	5,167
1990	2,272	12,969	170	15,411
1991	3,195	16,657	216	20,068
1992	3,007	27,881	968	31,939
1993	3,119	33,700	1,036	37,853
1994	1,962	34,191	2,391	38,544
1995	2,658	28,182	1,433	32,273
1996	3,826	37,942	1,339	43,107
1997	4,179	26,864	2,455	33,498
1998	4,284	18,339	614	23,237
1999	4,761	19,143	1,125	25,029
2000	7,917	28,749	637	37,303
2001	7,405	23,818	511	31,734
2002 <sup>d</sup>	6,219	24,360	141	30,720

tr = less than 1 metric ton. <sup>a</sup>Last year of foreign fishing in the Gulf of Alaska. <sup>b</sup>Last year of joint venture fishing in the Gulf of Alaska. <sup>c</sup>All catch from 1989 to the present is from the domestic fleet. <sup>d</sup>Includes catch to October 5, 2002.

Table 3.3. Composition of the 1994 to October 5, 2002 Gulf of Alaska flatfish catch by management category and North Pacific Fishery Management Council regulatory area.

	Area			Total	Percent total flatfish
	Western	Central	Eastern		
<u>1994</u>					
Shallow-water	189	3,742	12	3,943	30
Deep-water	21	2,836	272	3,129	23
Flathead sole	499	2,067	14	2,580	19
Rex sole	49	3,540	84	3,673	28
<u>1995</u>					
Shallow-water	366	5,057	7	5,430	39
Deep-water	96	1,895	222	2,213	16
Flathead sole	589	1,563	29	2,181	16
Rex sole	220	3,627	174	4,021	29
<u>1996</u>					
Shallow-water	443	8,876	31	9,350	46
Deep-water	19	1,954	220	2,193	11
Flathead sole	840	2,164	103	3,107	15
Rex sole	504	5,180	190	5,874	29
<u>1997</u>					
Shallow-water	400	7,328	47	7,775	45
Deep-water	13	2,644	1,007	3,664	21
Flathead sole	449	1,938	59	2,446	14
Rex sole	681	2,436	177	3,294	19
<u>1998</u>					
Shallow-water	270	3,204	91	3,565	35
Deep-water	16	2,182	88	2,286	22
Flathead sole	566	1,168	8	1,742	17
Rex sole	439	2,195	35	2,669	26
<u>1999</u>					
Shallow-water	268	2,298	11	2,577	29
Deep-water	22	1,865	398	2,285	26
Flathead sole	186	687	27	900	10
Rex sole	604	2,393	63	3,060	35
<u>2000</u>					
Shallow-water	560	6,319	49	6,928	53
Deep-water	27	816	142	985	8
Flathead sole	258	1,274	15	1,547	12
Rex sole	884	2,701	6	3,591	28
<u>2001</u>					
Shallow-water	207	5,955	0	6,162	52
Deep-water	18	667	119	804	7
Flathead sole	600	1,311	0	1,911	16
Rex sole	434	2,506	0	2,940	25
<u>2002</u>					
Shallow-water	223	5,970	2	6,195	5
Deep-water	17	521	8	546	53
Flathead sole	418	1,611	0	2,029	17
Rex sole	376	2,565	0	2,941	25

Table 3.4. Estimated catch of species in the shallow-water flatfish group by area for 1991 to November 3, 2001.

Shallow-water flatfish		Year	Western	Central	Eastern	Total
Rock sole sp.		91	2188	2108	0	4296
		92	2440	4766	0	7206
		93	407	7580	0	7987
		94	180	2251	11	2442
		95	332	3845	4	4181
		96	423	5752	0	6175
		97	313	5611	1	5924
		98	7	2095	52	2154
		99	180	1640	2	1823
		00	511	4481	49	5041
Northern rock sole		2001	83	2628	0	2711
		2002	133	2898	0	3031
Southern rock sole		2001	113	2349	0	2462
		2002	72	2051	0	2123
Alaska plaice		91	5	1	1	7
		92	2	3	0	5
		93	1	4	0	5
		94	0	1	0	1
		95	1	6	0	7
		96	1	64	0	65
		97	5	46	0	51
		98	0	18	1	19
		99	3	2	0	5
		00	<1	12	0	12
		2001	3	11	0	14
		2002	<1	4	0	4
English sole		91	2	71	0	73
		92	1	47	0	48
		93	6	77	0	83
		94	4	42	0	46
		95	3	42	0	45
		96	5	82	29	116
		97	16	70	45	131
		98	122	35	1	158
		99	1	14	0	15
		00	1	71	0	72
		2001	<1	50	0	50
		2002	2	20	0	22
Butter sole		91	8	562	0	570
		92	15	1351	0	1366
		93	8	1429	0	1437
		94	0	1057	0	1057
		95	23	894	0	917
		96	2	2351	0	2353
		97	15	979	0	994
		98	39	488	15	542
		99	0	420	9	429
		00	<1	1263	0	1263
		2001	3	702	0	705
		2002	<1	864	0	864

Table 3.4 Continued. Estimated catch of species in the shallow-water flatfish group by area for 1991 to November 3, 2001.

	<u>Western</u>	<u>Central</u>	<u>Eastern</u>	<u>Total</u>
<u>Sand sole</u>				
91	0	28	0	28
92	0	1	0	1
93	0	12	0	12
94	0	0	0	0
95	0	1	0	1
96	0	19	0	19
97	1	79	0	79
98	0	168	0	168
99	0	7	0	7
00	5	29	0	34
2001	<1	66	0	66
2002	0	4.5	0	5
<u>Yellowfin sole</u>				
91	4	51	0	55
92	6	51	0	57
93	2	35	0	37
94	4	148	0	152
95	5	60	0	65
96	12	55	0	67
97	42	156	0	198
98	0	121	20	141
99	81	10	0	91
00	21	43	0	64
2001	3	7	0	10
2002	16	<1	0	16
<u>Starry flounder</u>				
91	16	253	0	269
92	6	94	0	100
93	0	154	0	154
94	1	91	0	92
95	1	179	0	180
96	0	576	1	577
97	9	390	1	401
98	102	279	1	382
99	2	205	0	207
00	21	421	0	442
2001	2	142	0	144
2002	<1	128	2	130

Table 3.5. Estimated catch by species and area for the deep-water flatfish from 1991 to November 3, 2001.

	Western	Central	Eastern	Total
<u>Greenland turbot</u>				
91	430	16	0	446
92 <sup>a</sup>	233	1478	1301	3012
93	13	3	0	16
94	13	4	0	17
95	81	17	5	103
96	11	3	1	15
97	9	3	1	13
98	<1	6	66	72
99	10	5	6	21
00	25	<1	1	26
2001	<1	<1	0	<1
2002	<1	<1	0	<1
<u>Dover sole</u>				
91	751	8872	118	9741
92 <sup>b</sup>	106	8165	92	8364
93	93	3653	59	3804
94	8	2777	268	3053
95	15	1877	189	2082
96	8	1951	219	2178
97	4	2649	1007	3659
98	16	2138	20	2174
99	12	1860	392	2263
00	2	814	141	957
2001	<1	515	21	536
2002	<1	492	<1	492
<u>Deep-sea sole</u>				
91	0.1	1.5	0	1.6
92	0.2	2.3	0	2.5
93	0	3.1	0	3.1
94	0	3.3	0.6	3.9
95	0	1.3	0.1	1.4
96	0	0.4	0	0.4
97	0	1	0	1
98	0.0	38.1	1.8	39.9
99	0	<1	<1	<1
00	0	1	0	1
2001	0	<1	0	<1
2002	0	<1	0	<1

<sup>a</sup> Catch of Greenland turbot in the blend database was used for 1992 because estimated catch was lower than reported catch.

<sup>b</sup> Catch of Dover sole in 1992 estimated by subtracting Greenland turbot from the deep-water flatfish catch

Table 3.6. Dover sole, Greenland turbot and deep-sea sole catch 1978 to November 3, 2001. Average catch for Greenland turbot for 1978 to 1995 = 238 mt. Average catch for Dover sole for 1978 to 1995 = 1,969 mt. Average catch for Deepsea sole for 1978 to 1995 = 6.0 mt.

Year	Greenland turbot	Dover sole	deep-sea sole
1978	51	827	4.9
1979	24	530	5.1
1980	57	570	2.2
1981	8	457	8.3
1982	23	457	30.5
1983	145	354	11.1
1984	18	132	0.8
1985	<1	43	3.2
1986	<1	23	0
1987	44	56	0
1988	256	1087	0
1989	56	1521	0
1990	<1	2348	29.6
1991	446	9741	1.6
1992	3012	8364	2.5
1993	16	3804	3.1
1994	17	3053	3.9
1995	103	2082	1.4
1996	15	2178	0.4
1997	13	3659	1
1998	72	2174	39.9
1999	21	2263	<1
2000	26	957	1
2001	<1	536	<1
2002	<1	492	<1

Table 3.7. Catch(mt) from longline and trawl research cruises from 1977 to 1998.

Year	Dover	turbot	deepsea	Total Rock	N. Rock	S. Rock	Yellowfin	Butter	Starry	English	Sand	Alaska plaice	Flathead	Rex
1977	1.12	0.00	0.00	4.26			1.17	0.22	0.12	0.04	0.00	0.01	10.32	1.97
1978	5.99	0.30	0.00	44.72			3.76	2.61	1.85	1.74	3.69	0.39	23.65	8.47
1979	5.04	0.00	0.00	0.96			0.00	0.06	0.00	0.02	0.00	0.00	5.47	12.60
1980	0.92	0.04	0.00	15.83			8.98	2.70	0.98	0.31	0.31	0.48	29.70	4.64
1981	15.80	0.08	0.01	30.84			10.91	5.05	1.86	0.53	0.24	0.75	49.47	17.23
1982	5.71	0.03	0.00	26.15			2.48	3.45	1.07	0.64	0.16	0.19	20.07	7.73
1983	7.71	0.14	0.00	3.32			1.67	0.30	0.02	0.02	0.00	0.03	19.99	7.21
1984	15.79	0.18	0.01	19.10			9.08	1.88	0.97	0.39	0.09	0.17	39.33	18.27
1985	17.58	0.17	0.00	3.22			0.05	0.23	0.02	0.14	0.00	0.03	17.46	14.05
1986	1.25	46.79	0.00	4.18			4.09	0.08	0.03	0.13	0.00	0.03	41.42	3.74
1987	16.16	0.09	0.01	24.56			6.85	1.43	1.52	0.87	0.00	0.53	37.58	21.12
1988	0.06	0.01	0.00	0.37			2.56	0.00	0.01	0.00	0.00	0.03	2.70	0.08
1989	1.90	0.02	0.00	1.12			1.78	0.07	0.13	0.00	0.00	0.25	8.87	1.77
1990	11.65	0.02	0.00	11.13			2.84	0.94	0.44	0.31	0.01	0.30	22.50	11.99
1991	0.02	0.01	0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.01
1992	0.97	0.04	0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.04
1993	14.80	0.03	0.00	16.53			7.26	2.17	3.19	0.59	0.04	0.26	27.36	12.68
1994	0.06	0.07	0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.03
1995	0.00	0.01	0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
1996	7.39	0.04	0.00	0.44	5.08	7.06	3.67	0.96	0.94	0.37	0.05	0.35	14.46	7.04
1997	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
1998	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	1.58	4.09

Table 3.8. Percent retained catch for the Gulf of Alaska flatfish fisheries.

	Deep-water flatfish*	shallow-water flatfish	Flathead sole	rex sole
1991			59	
1992			66	
1993	90	82	66	
1994	75	73	67	89
1995	79	71	71	90
1996	72	86	77	95
1997	82	81	83	92
1998	90	83	83	97
1999	80	77	62	96
2000	73	88	83	97
2001	75	91	87	95
2002	64	91	86	95

\*Includes rex sole from 1991-93.

Table 3.9. Biomass estimates from the triennial trawl survey from 1984 to 2001. In 1984, 1987 and 1999 depths surveyed were to 1000 meters. In 1990, 1993 and 1996 depths were surveyed to 500 meters.

	1984	1987	1990	1993	1996	1999	2001
<u>Deep-water flatfish</u>							
Dover sole	68,525	63,397	96,602	85,422	79,531	74,365	68,211
Greenland turbot	292	143	0	0	0	0	0
Deep-sea sole	218	160	0	0	0	97	52
<u>Shallow-water flatfish</u>							
Rock sole total	137,472	123,221	159,452	173,361	206,343	166,603	190,297
Northern rock sole	-	-	-	-	78,845	61,081	64,240
Southern rock sole	-	-	-	-	127,390	105,522	126,057
Yellowfin sole	91,341	56,135	61,290	81,329	47,789	48,309	55,303
Butter sole	22,504	19,273	17,307	29,809	20,916	14,188	9,812
Starry flounder	14,293	14,141	10,907	40,288	27,309	46,652	76,418
English sole	3,202	7,243	-	8,403	7,946	14,432	14,166
Sand sole	1,216	82	-	479	940	234	357
Alaska plaice	1,912	4,830	-	2,583	4,870	8,680	3,639
Flathead sole	249,335	179,821	247,247	188,690	205,521	207,520	170,915
Rex sole	60,670	63,827	95,630	87,042	72,757	74,605	71,326

Table 3.10. Biomass estimates (t) for Gulf of Alaska flatfish, based on the 2001 bottom trawl survey, by North Pacific Fishery Management Council regulatory area and species.

Species	Area			Total
	Western	Central	Eastern	
<u>Deep-water flatfish</u>				
Dover sole	896	31,639	35,676	68,211
Greenland turbot	0	0	0	0
Deep-sea sole	0	52	0	52
<u>Shallow-water flatfish</u>				
Rock sole total	96,178	89,264	4,855	190,297
Northern rock sole	36,987	27,237	16	64,240
Southern rock sole	59,191	62,027	4,839	126,057
Yellowfin sole	49,586	5,612	105	55,303
Butter sole	3,338	5,578	896	9,812
Starry flounder	14,291	57,469	4,658	76,418
English sole	89	3,274	10,803	14,166
Sand sole	43	232	82	357
Alaska plaice	2,116	1,523	0	3,639
Flathead sole	67,787	85,961	17,167	170,915
Rex sole	9,624	41,723	19,979	71,326

Table 3.11. Survey biomass in the Eastern Gulf of Alaska for 1993, 1996 and 1999. The biomass used for the Eastern Gulf in 2001 is shown in the column labeled estimated 2001. See text for the method used to estimate the 2001 biomass.

Species	1993	1996	1999	Estimated 2001
Dover sole	39,664	40,928	38,612	35,676
Greenland turbot	0	0	0	0
Deepsea sole	0	0	0	0
Northern rock sole		0	31	16
Southern rock sole		3,323	6,355	4,839
Yellowfin sole	0	229	85	105
Butter sole	2,906	104	1,274	896
Starry flounder	5,193	1,518	7,262	4,658
English sole	5,341	5,713	10,803	10,803
Sand sole	8	183	56	82
Alaska plaice	0	0	0	0
Flathead sole	16,843	16,059	18,598	17,167
Rex sole	20,901	19,560	19,476	19,979

Table 3.12. Biomass estimates (t) for Gulf of Alaska flatfish, based on the 1999 bottom trawl survey, by North Pacific Fishery Management Council regulatory area and species.

Species	Area			
	Western	Central	Eastern	Total
<u>Deep-water flatfish</u>				
Dover sole	1,430	34,323	38,612	74,365
Greenland turbot	0	0	0	0
Deep-sea sole	0	97	0	97
<u>Shallow-water flatfish</u>				
Rock sole total	89,487	70,730	6386	166,603
Northern rock sole	44,731	16,319	31	61,081
Southern rock sole	44,756	54,411	6,355	105,522
Yellowfin sole	36,368	11,856	85	48,309
Butter sole	4,985	7,929	1,274	14,188
Starry flounder	10,627	28,763	7,262	46,652
English sole	563	3,066	10,803	14,432
Sand sole	61	117	56	234
Alaska plaice	5,647	3,033	0	8,680
Flathead sole	49,295	139,627	18,598	207,520
Rex sole	12,333	42,796	19,476	74,605

Table 3.13. Biomass estimates (t) for Gulf of Alaska flatfish, based on the 1996 bottom trawl survey, by North Pacific Fishery Management Council regulatory area and species.

Species	Area			Total
	Western	Central	Eastern	
<u>Deep-water flatfish</u>				
Dover sole	1,458	37,144	40,928	79,531
Greenland turbot	0	0	0	0
Deep-sea sole	0	0	0	0
<u>Shallow-water flatfish</u>				
Rock sole total	110,303	92,718	3,323	206,343
Northern rock sole	62,883	15,962	0	78,845
Southern rock sole	47,420	76,647	3,323	127,390
Yellowfin sole	29,857	17,704	229	47,789
Butter sole	6,265	14,547	104	20,916
Starry flounder	16,181	9,610	1,518	27,309
English sole	297	1,936	5,713	7,946
Sand sole	0	757	183	940
Alaska plaice	2,295	2,575	0	4,870
<u>Flathead sole</u>				
Flathead sole	66,732	122,730	16,059	205,521
Rex sole	9,419	43,778	19,560	72,757

Table 3.14. Biomass estimates (t) for Gulf of Alaska flatfish, based on the 1993 bottom trawl survey, by North Pacific Fishery Management Council regulatory area and species.

Species	Area			Total
	Western	Central	Eastern	
<u>Deep-water flatfish</u>				
Dover sole	2,371	43,388	39,664	85,422
Greenland turbot	0	0	0	0
Deep-sea sole	0	0	0	0
<u>Shallow-water flatfish</u>				
Rock sole total	88,644	83,163	1,554	173,361
Yellowfin sole	70,669	10,660	0	81,329
Butter sole	3,626	23,277	2,906	29,809
Starry flounder	3,778	31,318	5,193	40,288
English sole	1,189	1,874	5,341	8,403
Sand sole	81	390	8	479
Alaska plaice	1,667	917	0	2,583
<u>Flathead sole</u>				
Flathead sole	57,871	113,976	16,843	188,690
Rex sole	10,700	55,442	20,901	87,042

Table 3.15. Estimates of natural mortality, growth (von Bertalanffy k), and age of recruitment for the major Gulf of Alaska flatfish species.

Species	Natural mortality	Age at recruitment
Northern Rock sole	0.2	7
Southern Rock sole	0.2	8
Yellowfin sole	0.2	9
Rex sole	0.2	5
Dover sole	0.1	13

<sup>a</sup>Estimates are assumed the same as West Coast Dover sole (Turnock, et al 1994)

Table 3.16. Von Bertalanffy parameter estimates for principal flatfish species in the Gulf of Alaska.

Species		Linf	K	t0
Northern Rock sole(Stark and Somerton 2002)				
males		38.2	0.261	0.160
females		42.9	0.236	0.387
Southern Rock sole(Stark and Somerton 2002)				
males		38.7	0.182	-0.962
females		52.0	0.12	-0.715
Yellowfin sole 1987 survey				
males		32.8	0.19	-2.24
females		38.2	0.14	-2.18
combined		34.0	0.18	-1.82
Rex sole 1990 survey				
males		50.4	0.27	0.58
females		58.1	0.22	-0.47
combined		59.5	0.20	0.37

Table 3.17. Maturity schedule (proportion females mature at age) for Gulf of Alaska northern and southern rock sole used for ABC calculations.

Fraction mature

Age	Northern	Southern
1	0.00	0.00
2	0.00	0.00
3	0.00	0.00
4	0.00	0.00
5	0.02	0.01
6	0.24	0.04
7	0.72	0.15
8	0.93	0.37
9	0.98	0.63
10	0.99	0.82
11	1.00	0.91
12	1.00	0.96
13	1.00	0.98
14	1.00	0.99
15	1.00	0.99
16	1.00	0.99
17	1.00	1.00
18	1.00	1.00
19	1.00	1.00
20	1.00	1.00

Table 3.18. Food habits of flatfish. Percent observed stomach contents in parentheses where available (Livingston and Goiney, 1983).

Fish species	observed stomach contents
Rex sole	polychaetes, snow crabs, euphausiids, pandalus sp.
Flathead sole	various fishes(38%), mysids(36%), shrimp(15%), clams(6%), polychaetes(3%)
rock sole-adults	fish(40%) polychaetes(27%), clam siphons(10%)
rock sole-juveniles	fish(10%), polychaetes(45%), clam siphons(15%), gammarids(8%)
yellowfin sole	polychaetes, shrimp, fish, tanner crab, clam siphons
Dover sole	polychaetes(64%), crustaceans(11%), mollusks(18%), echinoderms(3%), coelenterates(3%)
English sole	polychaetes, ophiuroidea, ophiura sarsi, amphipoda, bivalves
sand sole	fish with a high frequency of arrowtooth flounder(only 4 stomachs out of 10 with food)
starry flounder	echiuroida(starfish), ophiuroidea(brittle star), fish, shrimp, crabs
butter sole	polychaetes, ophiuroidea, crustacea, shrimp, snow crab, fish

Table 3.19. Acceptable biological catch (t) for 2003 Gulf of Alaska flatfish, based on biomass estimates from the 2001 bottom trawl survey and  $F_{ABC}$ . Presented by North Pacific Fishery Management Council regulatory area. Split to Western, Central and Eastern management areas estimated by applying the average fraction of the catch in each area from 1991 to 1995. The split of the eastern management area into East Yakutat and West Yakutat/SE was calculated by using the 1999 survey biomass estimate.

	Area				Total
	Western	Central	West Yakutat	East Yakutat/SE	
<u>Deep-water flatfish</u>					
Dover sole	62	2,177	1,316	1,138	4,693
Greenland turbot <sup>a</sup>	122	40	9	8	179
Deep-sea sole <sup>a</sup>	0.1	4.2	0.1	0.1	4.5
<u>Total</u>	184	2,221	1,326	1,146	4,877
<u>Shallow-water flatfish</u>					
Northern Rock sole	6,205	4,570	0	0	10,778
Southern Rock sole	7,736	8,107	254	378	16,476
Total Rock sole	13,941	12,677	254	378	27,254
Yellowfin sole	6,581	745	5	8	7,340
Butter sole	740	53	66	1,302	2,161
Starry flounder	1,897	7,627	250	369	10,142
English sole	12	435	578	856	1,880
Sand sole	31	4	7	47	89
Alaska plaice	281	202	0	0	483
<u>Total</u>	23,483	21,743	1,160	2,960	49,349
Rex sole	1,277	5,537	1,599	1,053	9,466

<sup>a</sup> 0.75 \* Average catch used to calculate ABC level.

Table 3.20. Overfishing values (t) for 2003 for Gulf of Alaska flatfish, based on biomass estimates from the 2001 bottom trawl survey and  $F_{OFL}$ .

Species	Yield(t)
<u>Deep-water flatfish</u>	
Dover sole	6,182
Greenland turbot <sup>a</sup>	238
Deep-sea sole <sup>a</sup>	6
<u>Total</u>	6,426
<u>Shallow-water flatfish</u>	
Northern rock sole	11,550
Southern rock sole	22,664
Total rock sole	34,214
Yellowfin sole	9,556
Butter sole	1,695
Starry flounder	13,204
English sole	2,448
Sand sole	62
Alaska plaice	629
<u>Total</u>	61,807
Flathead sole	29,532
Rex sole	12,324

<sup>a</sup> Average catch used to calculate overfishing level.

Table 3.21. Projections to beginning of year 2004 for exploitable biomass and yield taken in year 2004, using  $F=0$ ,  $F_{ABC}$ ,  $0.5 * F_{ABC}$ , and average  $F$  from 1995 to 1999.  $F_{ABC}$  is 0.15 for flathead and rex sole.  $F_{ABC}$  is 0.17 for rock sole and 0.15 for all other shallow water flatfish. For these projections the deep water group includes only Dover sole. The  $F_{ABC}$  is 0.075 for Dover sole.

Species group	Fishing mortality	total biomass (t)	Yield
Rex sole	F		
	0	78,271	0
	ABC	69,030	9,217
	0.5*ABC	73,483	4,775
	Avg F	74,569	3,691
Deep water	F		
	0	60,053	0
	ABC	56,014	4,219
	0.5*ABC	57,996	2,149
	Avg F	58,167	1,969
Shallow water	F		
	0	401,159	0
	ABC	348,237	53,264
	0.5*ABC	373,669	27,668
	Avg F	395,010	6,220

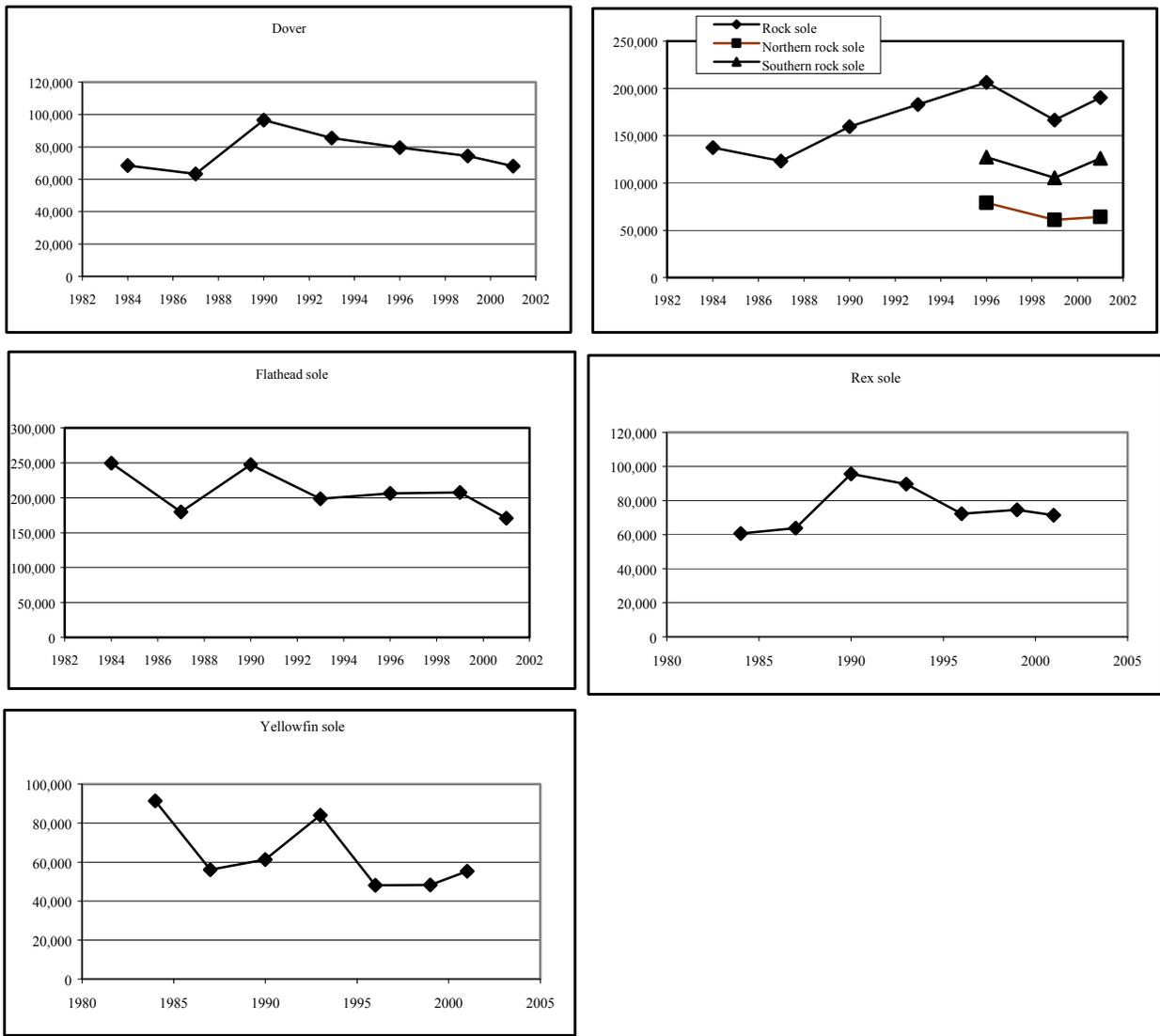


Figure 3.1. NMFS survey biomass estimates by species for 1984 to 2001.

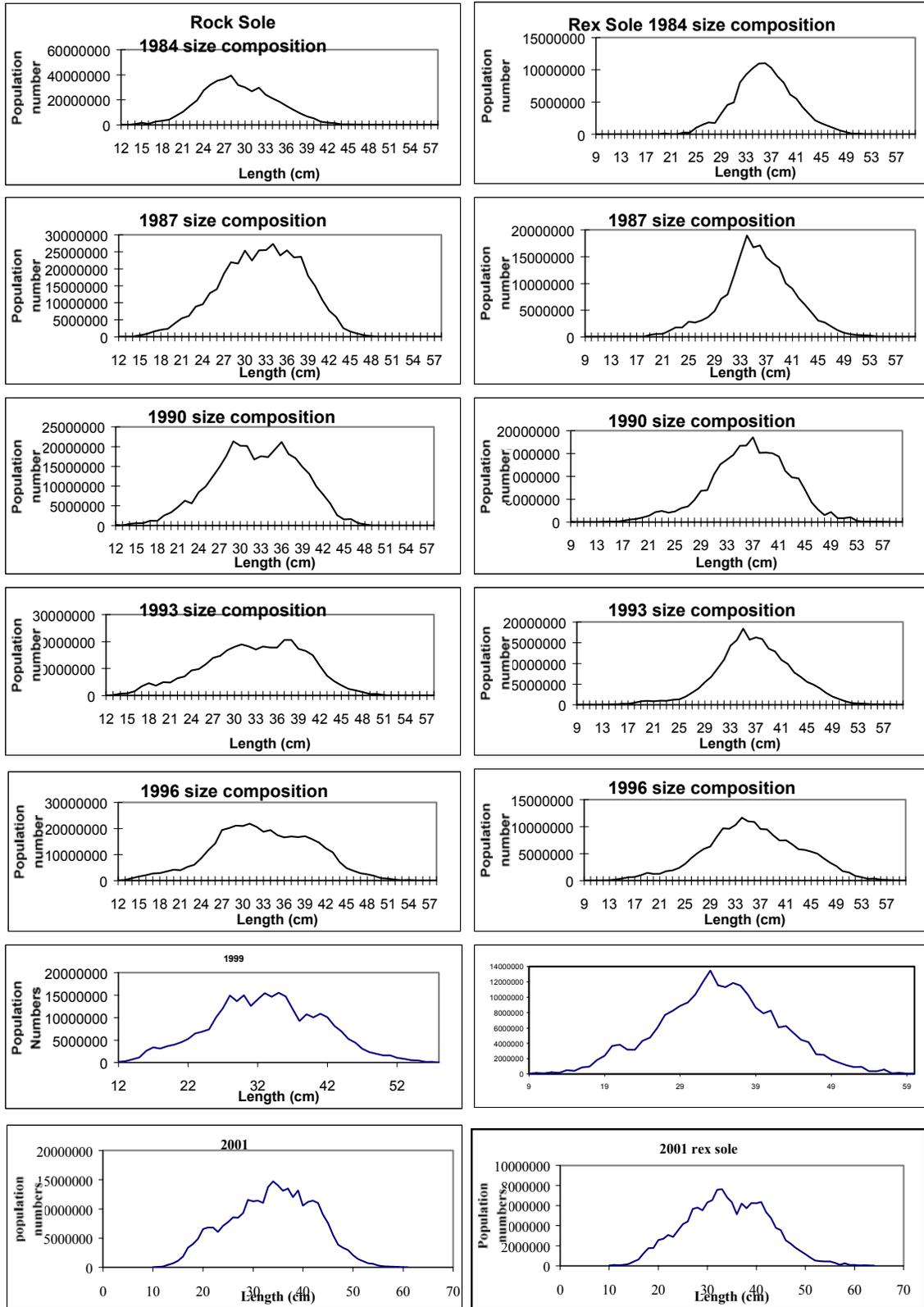


Figure 3.2. Population size composition of the six major flatfish species estimated from triennial trawl surveys conducted from 1984-2001.

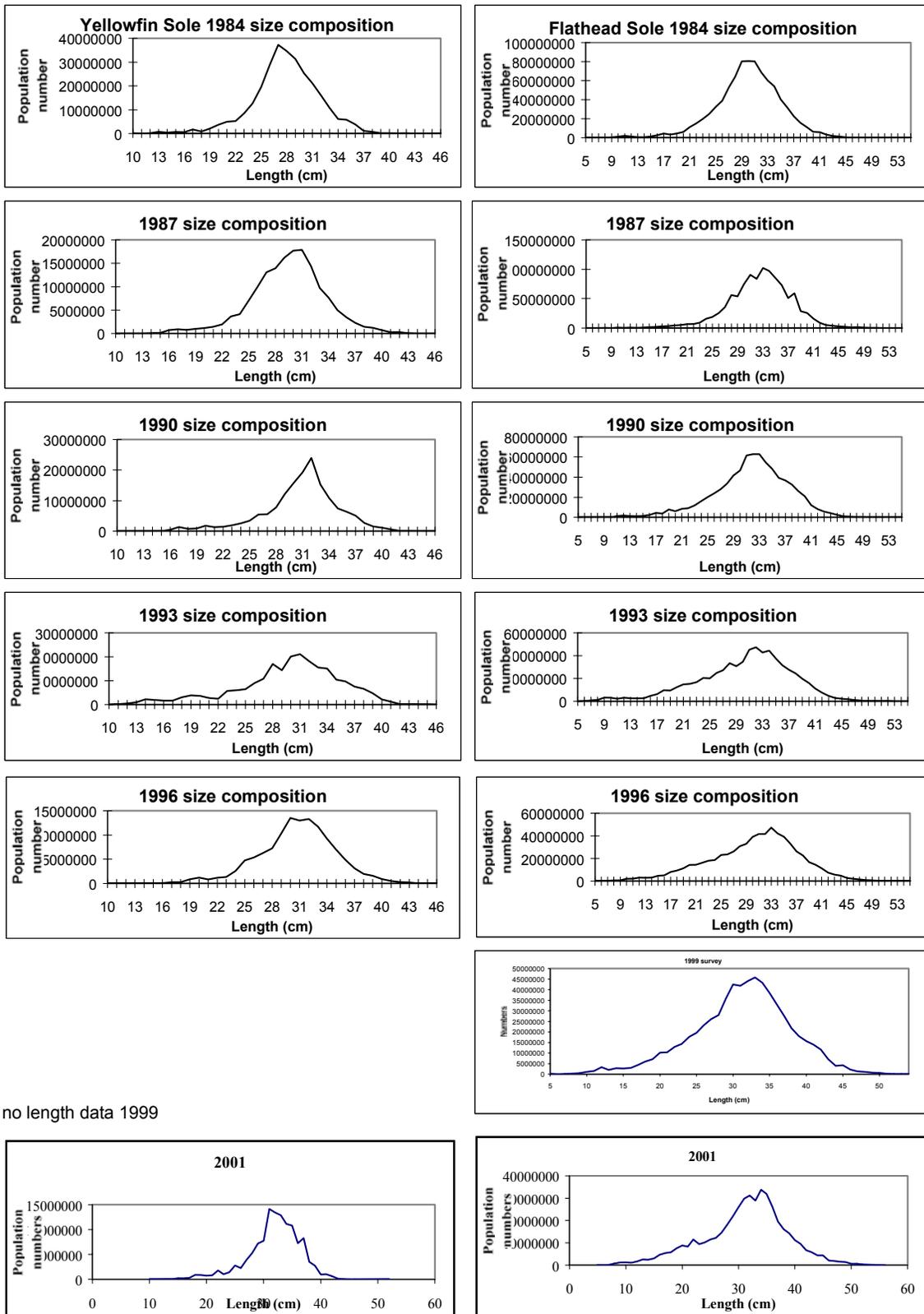


Figure 3.2. Continued. Population size composition of the five major flatfish species estimated from the triennial trawl surveys conducted from 1984-2001.

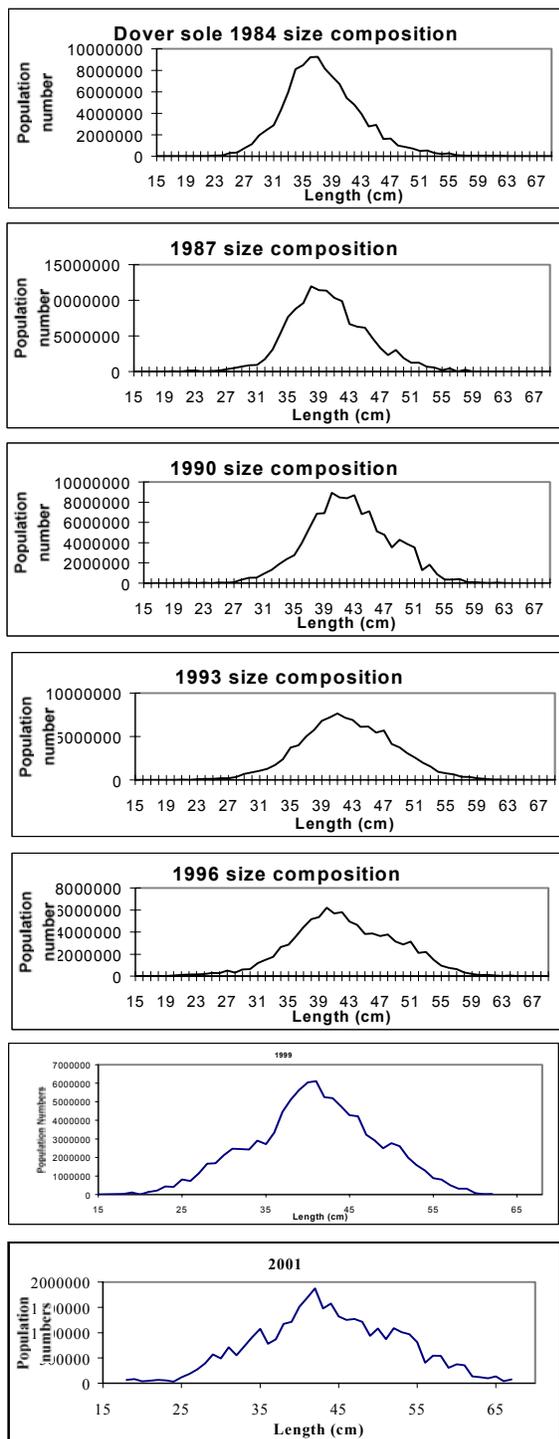


Figure 3.2. Continued. Population size composition of the five major flatfish species estimated from the triennial trawl surveys conducted from 1984-2001.

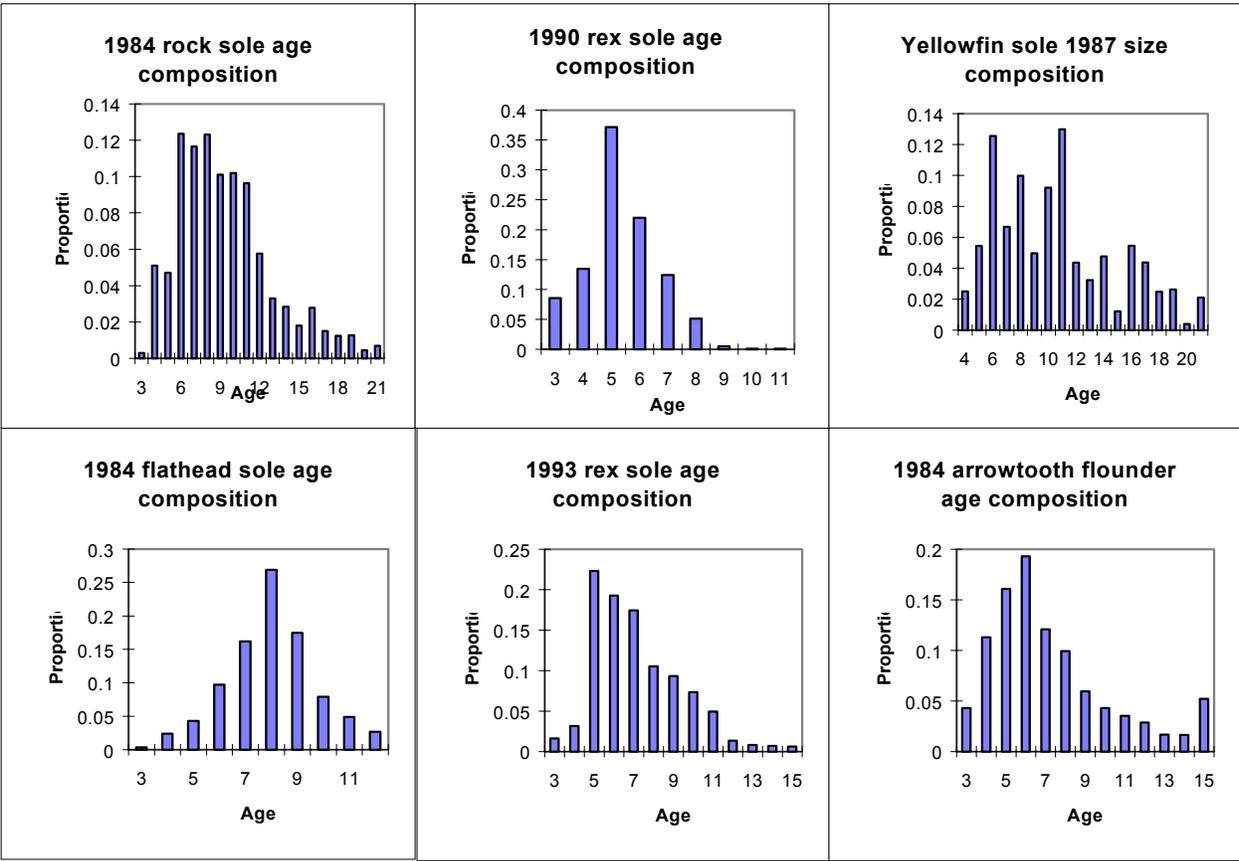


Figure 3.3. Flatfish age compositions from NMFS surveys.

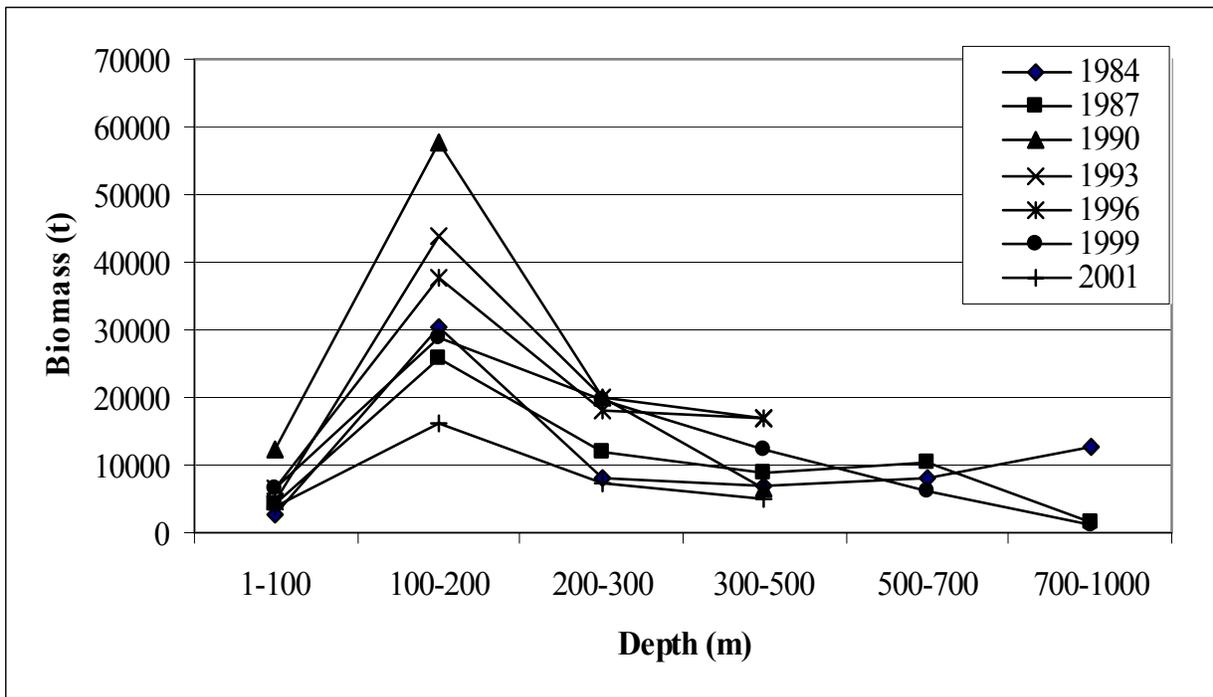


Figure 3.4. Dover sole biomass by depth for surveys from 1984 to 2001. The 1984, 1987 and 1999 surveys covered depths to 1000 m. The 1990, 1993, 1996 and 2001 surveys went to 500 m. The 2001 survey biomass shown here does not include the eastern gulf. Approximately half of the biomass has been from the eastern gulf for surveys previous to 2001.

